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THE COMPARATIVE MORPHOLOGY OF THE MALE GENITALIA OF THE LEPIDOPTEROUS FAMILY HEPIALIDÆ.

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INTRODUCTION.

The male genitalia of Lepidoptera have long been a subject of study by both the insect morphologist and the systematic entomologist. As a result of this study two complete systems[1] of nomenclature have arisen for the sclerites and appendages comprising this organ.

The morphologist, interested primarily in homologies, has formulated a system based on the somatic structure of insects and equally applicable to all orders of the Hexapoda. The most prominent investigators of this problem from a morphological standpoint are Burmeister, Kolbe, Peytoureau and Berlese. A. G. Newell, Annals of the Entomological Society of America, June, 1918, has carefully homologized the morphological systems of terminology throughout all the main orders of insects.

The taxonomist, interested particularly in the discovery of specialized structures to serve as criteria for the differentiation of genera and species, has originated a descriptive terminology based on the structure and position of the particular part designated, applicable only to Lepidoptera and often restricted to that family

[1] A third system of nomenclature used by European writers with reference to the Apterygotoid, Neuropteroid and Orthopteroid forms has been homologized by G. C. Crampton, BULLETIN BROOKLYN ENTOMOLOGICAL SOCIETY, 1918, and is not discussed in this paper.

or group in which the investigator specialized. F. N. Pierce, a British lepidopterist, has probably contributed more to our knowledge of the systematic value of Lepidopterous genitalia than any other author. The systematic schema of terminology is adapted from his two works, "The Genitalia of the Noctuidæ" and "The Genitalia of the Geometridæ."

The primary object of this paper is to homologize these two systems of nomenclature by a comparative study of the most primitive family of the order Lepidoptera, namely the Hepialidæ.

The male genitalia of many Neuropteroids, Trichoptera and all available families of Lepidoptera have been examined in connection with the preparation of this paper, but only the Hepialidæ are figured, for they best accomplish this purpose.

Terminology

The abdomen of the typical lepidopteron consists of eleven segments designated by the morphologist as somites, the dorsal chitinized portion being called the tergum and the ventral chitinized portion, the sternum. The genitalia proper are formed by the telescoping and anastomosing of the last four abdominal somites (8, 9, 10, 11) accompanied by a structural modification of their respective appendages (I, II, III, IV) according to function. In the Hepialidæ this telescoping has taken place to a much less extent than in any other of the Lepidopterous families, the somites retaining a more generalized condition in regard to the shape of their terga and sterna and the relative positions of their respective appendages.

In all higher Lepidoptera, somites 1–7 possess a pair of spiracles located on the lateral margins of the sternum; in the Hepialidæ somite 8 also retains a well-developed pair of spiracles.

Those structures constituting the genitalia proper may be described and homologized as follows (see Fig. 1):

Somite 8:

Tergum: A simple unmodified chitinous plate.

Sternum: A small rectangular ventro-cephalic plate and a broader curved, invaginated V- or U-shaped portion, the Vin-

culum of systematists, formed by a pocketing in of the caudal margin of this sclerite.

Appendage I: A pair of finger-like processes, the Harps of Pierce, associated superficially with the ninth sternum, as in the case of all Lepidoptera, but attached laterally and ventrally to the lateral margin of the eighth sternum, thus showing their relation to it.

In the systematic terminology of Pierce, the basal inner portion of this appendage is termed the Sacculus and the outer free lobe, the Valva. In the Hepialidæ the Harps are so little differentiated that this terminology is scarcely applicable. The term Claspers has been loosely applied to these appendages but this term should be strictly confined to specialized structures described by Pierce on the inner surface of the Harp. These, as well as other structures belonging to the Harp which are so characteristic of higher Lepidopterous genitalia, do not occur in the Hepialidæ.

SOMITE 9:

Tergum: Heavily chitinized, deeply emarginate or divided on the meson and forming the dorsal hood-like portion of the genitalia. This is called the tegumen by Pierce and together with the anastomosed eighth and ninth sterna is referred to as the tegumenal ring. The tegumen and vinculum together with the Gnathos and Uncus are known as the external part of the male genitalia.

Sternum: A simple chitinized plate situated beneath appendage I but only superficially connected with it. Sternum 9 in the higher Lepidoptera forms the basal portion of the penis and is known as the Anellus while its appendage (Appendage II) together with the appendage of somite 10 (Appendage III) form the remainder of the chitinous sheath through which the penis opens and is designated the Ædœagus by Pierce. The basal part of the Anellus is often modified into a chitinized spinous or scobinate plate, the Juxta. In the Hepialidæ, however, somite 9 possesses no appendage, and the penis, a membraneous internal structure passes behind sternum 9 and opens caudad to sternum 10.

Somite 10:

Tergum A divided sclerite interrupted dorsally by the opening of the anus and crowded out of position by the enormous tergum 9. Ventrally the two portions of this sclerite are united to the small, square, tenth sternum. In the higher Lepidoptera, tergum 10 is often produced above the anus into a dorsal hood or hook, the Uncus of Pierce.

Sternum: A small square or rectangular sclerite, ventrad to the anus, simple in the genera *Pielus* and *Gorgopis* but in *Hepialus* and *Stenopis* possessing a spatulate, median appendage, articulated by an elbow joint and probably serving as an intromittent organ for the penis which opens just behind it. Sternum 10 is plainly homologous with the Gnathos or Subscaphium of Pierce as its position ventrad to the anus would indicate. Whether its appendage, in *Hepialus* and *Sthenopis* is homologous with appendage III, the distal part of the Ædœagus, is rather questionable and its occurence is too inconstant to substantiate any definite conclusion. Its function, however, is undoubtedly the same as that of the Ædœagus of the higher Lepidoptera.

Somite 11: Tergum and sternum 11 are not developed in this family except in the genus *Gorgopis* having been supressed by the invagination of the anus within tergum 9. In *Gorgopis* tergum 11 is well developed forming a hood-like Scaphium covering the anus dorsally and laterally.

The Cerci which are regarded as appendages of somite 11 (Appendage IV) are lacking. In the genera *Gorgopis* and *Pielus* tergum 9 bears a pair of small chitinous processes caudad to the first pair found in all the genera examined, and dorsad to the anus, a position suggestive of Cerci, but their structure and articulation would indicate that they are only a secondary pair of processes.

In the higher Lepidoptera there is a pair of appendages laterad to the Uncus and attached to tergum 9. These are called Socii and are probably homologous with the Cerci although it is barely possible that they are structures developed independently within the order Lepidoptera and in no way

homologous with the Cerci of the Neuropteroid and Orthopteroid insects.

Discussion.

A brief resumé of those genera of the Hepialidæ which were studied will serve to contrast their respective characteristics as well as to emphasize the generalized condition of the male genitalia in this family.

Hepialus.

This genus seems to be the most primitive of those studied. Sternum 8 is only slightly invaginated, forming a broad U-shaped Vinculum, while the greater portion of it remains typical in shape and position. Sternum 9 is a broad, pentagonal sclerite closely associated with the Harps and only slightly fused with sternum 8. Tergum 9 is a simple hood-like sclerite forming the dorsal wall of the Tegumen and bearing a small pair of chitinous processes on its ventral margin. Sternum 10 is a small square sclerite bearing a median process (Appendage III) functioning as an intromittent organ and foreshadowing the Ædœagus of higher forms. The Ductus Ejaculatorius opens caudad to sternum 10 just beneath appendage III. Tergum 10 consists of two small sclerites laterodorsad to sternum 10 and articulating laterally with tergum 9. Sternum and tergum 11 are absent. Species examined: *Hepialus lupulinus* L. and *H. gracilis* Grt. (Fig. 2).

Sthenopis.

This genus resembles *Hepialus* quite closely in its main structural features. Sternum 8 is more deeply invaginated, the caudad margin strongly emarginate around the Vinculum and the lateral and cephalic margins of the sclerite are indistinct. The fusion of sternum and tergum 10 with appendage III is more marked and the resulting structure forms a suspensorium articulated laterally to tergum 9. The Ductus Ejaculatorius which opens between the arms of this suspensorium and appendage III is attenuated into a triangular process. The chitinous processes of tergum 9 are longer and more spinous than in *Hepialus* and are differentiated

into a primary and a secondary pair. Species examined: *Sthenopis humuli* and *S. thuli* L. (Fig. 3).

Gorgopis.

In this genus the fusion of terga 9 and 10 with the chitinous processes of tergum 9 has resulted in the formation of two large lobate processes located on either side of the opening of the Ductus Ejaculatorius and attached basally to tergum 9, leaving sternum 10 as a small isolated sclerite in the conjunctiva caudad to sternum 9. The probable function is as an intromittent organ. Tergum 9 is enlarged into a dorsal hood surrounding the base of the anus and bears a small pair of secondary chitinous processes on its inner dorsal margin. The preservation of tergum 11 in this genus has been previously discussed. It is figured as a hood-like structure with well chitinized lateral margin dorsad to the anus. Species examined: an undetermined species in the Cornell University collection (Fig. 4).

Pielus.

This genus presents the extreme of specialization by fusion. The Vinculum is large, heavily chitinized and completely isolated from the remaining uninvaginated portion of sternum 8 but situated dorsad to it. Sternum 9 is heavily chitinized, firmly attached to the Vinculum by conjuctiva and bears on its lateral margin a small pair of Harps. Tergum 9 is enormously enlarged, heavily chitinized and bears a primary and secondary pair of processes. Sternum and tergum 10 are small and firmly articulated to tergum 9. Appendage III is lost through the approximation of sternum 10 and the primary processes of tergum 9. These latter probably function as the intromittent organ. The opening of the Ductus Ejaculatorius is just caudad to sternum 10 and dorsad to these processes (Fig. 5). Species examined: *Pielus labyrinthicus.*

Summary

By careful comparison it has been found possible to homologize the taxonomic terminology of Pierce and other systematists with

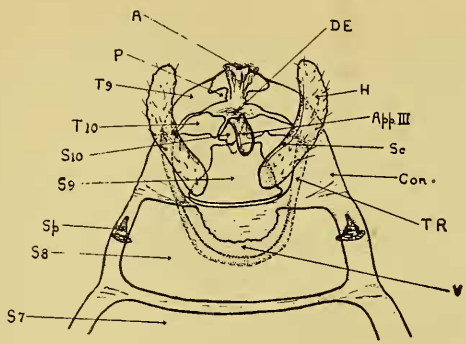

Fig. 1

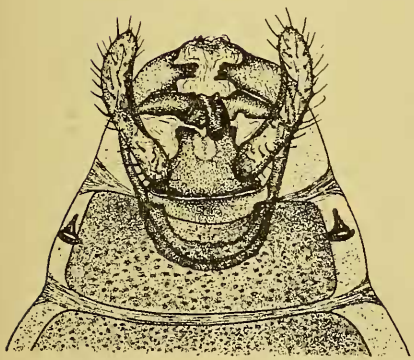

Fig. 2

Fig. 3

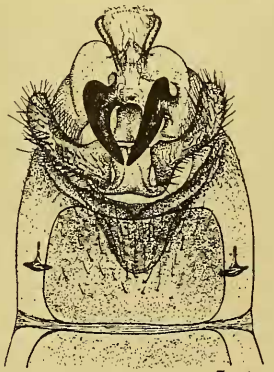

Fig. 4

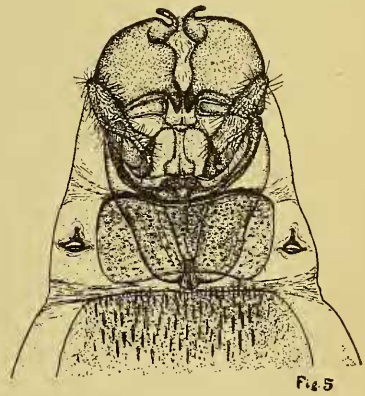

Fig. 5

PLATE I.
Genitalia of Hepialidæ—J. E. Eyer del.

those morphological units comprising the male genitalia of adult Lepidoptera. The male genitalia of the family Hepialidæ have proved most helpful in accomplishing this because they have retained the primitive relation of the somites and their respective appendages. The absence of a true Ædœagus, the various modifications of somite 10 and appendage III to function as an intromittent organ, the association of the Harpes (App. I) with sternum 9 and the retention of the eighth abdominal spiracle are the most striking features in the morphology of the male genitalia of this family.

Acknowledgments.

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Expanation of Plate.

Abbreviations.

S7—Sternum 7.
S8—Sternum 8.
V—Vinculum.
Sp—Spiracle of Somite 8.
Con—Conjunctiva.
S9—Sternum 9.
T.R.—Tegumenal Ring.
Sc—Sacculus of Harpe.
App III—Appendage of Somite 10.
S10—Sternum 10.
T10—Tergum 10.
D.E.—Opening of Ductus Ejaculatorius.
P—Chitinous Process.
T9—Tergum 9.
A—Anus.

Figures.

Fig. 1. Male Genitalia of *Hepialus lupulinus* L., ventral aspect; parts spread and labeled.
Fig. 2. *Hepialus lupulinus* L.
Fig. 3. *Sthenopis humuli.*
Fig. 4. *Gorgopis* sp.
Fig. 5. *Pielus labyrinthicus.*